DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Proposal Submission

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

The topics published in this solicitation are broad in scope. They were developed to bring the small business community and research partners together to meet the technological needs of today. DARPA has identified 9 technical topics, numbered **DARPA ST00-001** through **DARPA ST00-009** to which small businesses may respond in the fiscal year (FY) 2000 solicitation. Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. Full topic descriptions, which originated from DARPA technical offices, are included.

Please note that **an Original and four copies** of each proposal must be mailed or hand-carried; DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

It is expected that the majority of DARPA Phase I awards will be Firm Fixed Price contracts. Phase I STTR proposals **shall not exceed $99,000**, and are for approximately one (1) year efforts. DARPA Phase II proposals **must be invited** by the respective Phase I DARPA Program Manager (with the exception of Fast Track Proposals - see section 4.5). Phase II STTR awards will be limited to $500,000, and it is expected that a majority of the Phase II contracts will be Firm Fixed Price-Level of Effort.

The responsibility for implementing DARPA's Small Business Technology Transfer (STTR) Program rests with the Office of Administration and Small Business (OASB). The DARPA SBIR/STTR Program Manager is Connie Jacobs. DARPA invites small businesses, in cooperation with a researcher from a university, an eligible contractor-operated federally-funded research and development center (FFRDC), or a non-profit research institution, to send proposals directly to DARPA at the following address:

DARPA/OMO/CMD/STTR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714

(703) 526-4170
Home Page http://www.darpa.mil

STTR proposals submitted to DARPA will be processed by DARPA OMO/CMD and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution." (refer to section 4.2 Evaluation Criteria - Phase I - page 7), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may fund no proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

In order to ensure an expeditious award, cost proposals will be considered to be binding for a period of 180 days from the closing date of this solicitation. For contractual purposes, proposals submitted to DARPA should include a statement of work which does not contain proprietary information. Successful offerors will be expected to begin work no later than 30 days after contract award. For planning purposes, the contract award process is normally completed within 30 to 60 days from issuance of the selection notification letter to Phase I offerors.

On a pilot basis, the DoD STTR program has implemented a streamlined Fast Track process for STTR projects that attract matching cash from an outside investor for the Phase II STTR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications to be submitted during the last two months of the Phase I effort. Technical dialogue with DARPA Program Managers is encouraged to ensure research continuity during the interim period and Phase II. If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will not exceed $40,000.

DARPA FY 2000 Phase I STTR
Checklist

1) Proposal Format

   a. Cover Sheet (identify topic number) ______
   b. Project Summary ______
   c. Identification and Significance of Problem or Opportunity ______
   d. Phase I Technical Objectives ______
   e. Phase I Work Plan ______
   f. Related Work ______
   g. Relationship with Future Research and/or Development ______
   h. Commercial Strategy ______
   i. Key Personnel ______
   j. Facilities/Equipment ______
   k. Consultants ______
   l. Prior, Current, or Pending Support of Similar Proposals or Awards ______
   m. Cost Proposal ______
   n. Company Commercialization Report ______
   o. Agreement between the Small Business and Research Institution (upon Contract Award) ______

2) Bindings

   a. Staple proposals in upper left-hand corner. ______
   b. **Do not** use a cover. ______
   c. **Do not** use special bindings. ______

3) Page Limitation

   a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______
   b. Company Commercialization Report is not included in the page count. ______

4) Submission Requirement for Each Proposal

   a. Original proposal signed. ______
   b. Four photocopies of original proposal, including signed cover sheet and project summary. ______

INDEX OF DARPA FY 2000 STTR TOPICS

SUBJECT/WORD INDEX TO THE DARPA FY 2000 STTR TOPICS

DARPA FY2000 STTR TOPIC DESCRIPTIONS

DARPA ST00-001 TITLE: Palm Power

KEY TECHNOLOGY AREA: Materials / Processes; Sensors, Electronics and Battlespace Environment; and Human Systems.

OBJECTIVE: Design and build a cost effective portable power system capable of delivering 5 W of continuous power for 72 hours with a maximum system mass of 0.5 kg. and system volume of one liter (including fuel, if necessary).

DESCRIPTION: Batteries are the primary power source for portable electronic devices. While the energy density and specific energy of batteries is increasing, scenarios are being developed that will require far more energy than can be delivered by batteries alone. Fueled systems are attractive because the energy content of many fuels is very high and only modest conversion efficiencies are required to greatly exceed the specific energy and energy density of batteries. The major challenge is scaling these systems down to sizes that can be carried or worn and used to power portable electronic devices such as communication radios or laptop computers. Load following capability for energy conversion devices in these size ranges add significantly to this challenge. In practice, hybrid systems that include rechargeable batteries are likely to emerge for these applications as the battery can handle peak power and air independent operation requirements. Small energy conversion devices will have a better chance of succeeding in the near term if the load following requirement can be relaxed. The focus of this solicitation is strictly on a prime power system that can meet the requirements stated above. It has been demonstrated recently that small direct methanol fuel cells stacks can deliver 60% of the performance of equivalent hydrogen/air stacks under mild operating conditions. At the system level direct methanol fuel cell performance could meet or exceed that of the hydrogen fuel cell when hydrogen storage and/or generation are included in the system weight and volume of the latter. While the direct methanol fuel cell might be an ideal technology to meet the goals of this solicitation, other technologies, e.g., thermoelectrics, thermionics, AMTEC, metal-air systems, etc. will be considered. Regardless of the technology, fuel materials choice must be compatible with consumer safety and transportation regulations and thermal and acoustic signatures must be extremely low. The final device must be amenable to manufacture at a reasonable price. This solicitation is for the development of the prime power generator and balance of plant (components necessary to control and provide reactant feed, product removal and thermal balance) only. No consideration will be given for the development of complete hybrid systems.

PHASE I: Demonstrate a breadboard system that will lead to a design capable of meeting the program objectives. The design must be supported by data obtained from breadboard testing.

PHASE II: Build and test a packaged system that meets the program objectives and can be stored and operated under military conditions. Deliver six complete systems for testing and evaluation.

PHASE III DUAL USE APPLICATIONS: These systems could be used for a wide range of man portable power applications, e.g., radios and laptop computers for military and consumer markets. In addition, they could be used as long endurance power sources for remote sensing and surveillance.

KEYWORDS: Energy Sources, Power Sources, Direct Methanol Fuel Cell, Static Energy Conversion.

REFERENCES: S. Gottesfeld, “Recent Advances In Direct Methanol Fuel Cells At Los Alamos National Laboratory”, presented at the Sixth Grove Fuel Cell Symposium, 13-16 September 1999, London, England, and submitted to the Journal of Power Sources (1999).

DARPA ST00-002 TITLE: Dynamic Database for Biology Research

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: Design and build a high performance knowledge based system for biology base query.

DESCRIPTION: Biomedical data is multifaceted, enormous in quantity, with new critical information, both in type and scope, being continuously generated. This information spans numeric, categorical (e.g. sequence databases) and visual types (e.g. photographs), as well as different sources, storage types, and formats. Current efforts (NIH, Celera Genomics, etc.) generate large amounts of raw data to populate databases. Special algorithms and labor-intensive transfer of data from primary databases are required for any non-standard analyses and significant effort is required to incorporate the results directly for immediate use. User-friendly software tools that provide users with the ability to add specialized annotations to rapidly expanding databases without requiring the writing of new programs are needed. These high performance knowledge based (HPKB) systems will allow researchers to focus on data mining, analyzing information in the database, and developing useful applications that rapidly access, process, and query biomedical information for key applications (e.g. drug design, pharmacogenomics, and modeling of cells and organs).

PHASE I: Develop a high performance database testbed for computational biology research
PHASE II: Develop and demonstrate a specific database query of significant interest to computational biology

PHASE III DUAL USE APPLICATIONS: Besides the medical applications of geonomic sequencing and drug design, Dynamic Database tools can be applied to quick identification of chemical-bio agents.

KEYWORDS: Database, Data Mining, Biology.

REFERENCE: list of the major databases and links for genomics work:
1. http://www.ornl.gov/TechResources/Human_Genome/links.html#informatics
2. http://www.unl.edu/stc-95/ResTools/biotools/biotools4.html
The Genbank Sequence database at NIH
3. http://www.ncbi.nlm.nih.gov/Genbank/index.html

DARPA ST00-003 **TITLE: Extremely Low-Cost, Compact Wireless Network Interface Modules**

KEY TECHNOLOGY AREA: Information Systems Technologies

OBJECTIVE: To develop new techniques in RF, ultra-wideband and Infrared network interface technologies for the next generation compact wireless modules that are several orders of magnitude lower in cost and of miniature size and low-power needs.

DESCRIPTION: Extremely low cost, compact wireless network interface technology is a key to triggering a quantum shift in the types, volumes and roles of the devices that are attached to the global networking infrastructure. Such wireless input/output (IO) devices will support ubiquitous use of processors, sensors, and actuators in the environment enabling such applications as: Smart Battlefield, Collaboratories, Intelligent Highways/ Hospitals/Buildings, Geological and Environmental Monitoring. Crisis management centers, in response to events such as earthquakes, forest fires, floods or hurricanes, could quickly and effectively link sensors assessing damage to communication/processing devices carried by response teams to provide a systematic view of the situation and make informed decisions. "Guardian Angels" could autonomously monitor safety and health information related to high risk individuals (e.g., soldier or home care patients) and assets (e.g., aircraft). Today's wireless interface modules are limited both in terms of cost, size, and power requirements. Next generation modules that are several orders of magnitude lower in cost and of miniature size and low-power need to be developed. The operational transmission span of interest is in the range of few meters to low kilometers though a single module may or may not cover this entire range. Techniques in RF, ultra-wideband, and IR technologies need to be explored.

PHASE I: Begin a feasibility design study of cost reduction and performance prediction of compact wireless network interface module that can eventually be mass- produced at a very small fraction of cost compared to today's state-of-the-art. While the strongest emphasis is on the physical layer design, preliminary design analysis should be made for the link layer, network layer and transport layer processing. The physical layer implementation may be based on RF, ultra-wideband, infrared or any other viable spectral domain.

PHASE II: Integrate the sub-components into a network I/O module prototype and into an end-system prototype. Demonstrate functionality of the integrated system prototype in both a laboratory and outside environment that emulate real-world settings. Carry out a thorough testing and characterization study. Phase II must also include a prototype demonstration for key sub-components that make up the module. An analysis of the expected system performance within the parameters of interest and estimates of projected cost reductions by an order of magnitude anticipated is also strongly encouraged.

PHASE III DUAL USE APPLICATIONS: Commercialization of the system should be pursued in this phase. Chart a course for further improvements and refinement to the component and system design. Detailed study of usage in domain-specific applications is also highly encouraged. Industrial consortia or other standardization activities are also encouraged.. The resulting technology could be directly utilized to connect sensors, actuators and communication devices into the Internet, and these end-devices may be widely and deeply embedded in homes, buildings, vehicles, urban and natural environments, or carried/worn by users.

KEYWORDS: Networking, Embedded Systems, Wireless Communications, Infrared Communications, Ubiquitous Networking

DARPA ST00-004 **TITLE: Programming Support for Embedded Real-Time Systems**

KEY TECHNOLOGY AREA: Information Systems Technologies

OBJECTIVE: Develop programming support technology that will simplify the introduction and assurance of essential properties of real time embedded software (e.g., deterministic timing, composability, fault tolerance, memory management, and synchronization) and assurance of domain-specific properties.

DESCRIPTION: Development of software for real-time embedded systems remains a highly labor-intensive and error prone process. Because of the physical constraints under which it must operate, embedded software must augment the code that realizes the system's intended functionality with code necessary to assure cross-cutting properties such as timing, fault-tolerance, and application-aware resource management (e.g., register, memory, and cache management). The nature of this "aspect" code requires that it (a) be customized to the underlying hardware platform; (b) be tightly interleaved with the functional code; and (c) be highly optimized to minimize overhead and interference. The considerable programming effort entailed in generating such code has led to hard-coded, application-specific, hand-tuned solutions that make the software brittle and vulnerable to inevitable changes in processor, board, and bus architectures and inhibit subsequent adoption of advances in subsystem or component technologies (e.g., sensors, actuators). As system functions are increasingly allocated to software, the problem of efficiently constructing large but robust and reliable embedded software systems becomes both a cost driver and a system risk factor. Current programming practice will not scale to future systems, particularly those that may depend on adaptive, mobile, embedded software. Automation of embedded software development will require tools that allow the programmer to separate the concerns of the aspect requirements from that of the functionality. Such tools, along with reusable aspect-enforcing mechanisms, such as protocols or services, would support rapid, reliable programming of cross-cutting aspects such as timing, fault tolerance, concurrency, synchronization, atomicity, storage hierarchy management, data persistence, and other demands. Research is therefore sought that enables tool-based introduction of these cross-cutting aspects into embedded functional code and provides assurance that the required properties are achieved. These tools should provide strong support for code analysis and transformation. Of particular interest are approaches that target mobile code and facilitate staged introduction of aspects.

PHASE I: Design a programming framework for embedded software that will enable aspect- and object-oriented software development, and property-based debugging. The framework should provide ground-breaking technology that radically simplifies programming and validation of real-time embedded software. For example, the environment should provide interpretation and analysis support to determine when cross-cutting aspects may interact. It should insert the required implementation mechanisms into the software, detect interference among properties, and aid the programmer in compensating for it. The framework should be populated with reusable protocols or service suites addressing timing properties and at least one additional cross-cutting aspect. Of particular interest are approaches that support domain-specific software development and real-time mobile code. Phase I products include (a) design of the overall framework; (b) description of key components including analysis and transformation tools, protocols, and service suites; (c) proof-of-concept demonstrations of key analysis and transformation algorithms; and (d) an experimentation plan for demonstrating the software development technology on a challenging and useful real-time embedded software problem.

PHASE II: Demonstrate the programming framework concept by implementing and applying it to the class of real-time embedded systems challenge problems defined in Phase I. A robust reference implementation of the framework should be completed. The programming framework should be exercised on several examples of the class of software chosen for the challenge area and on at least two different hardware platforms.

PHASE III DUAL USE APPLICATIONS: The technology produced must have a high probability of successful commercialization. Commercialization and commercial application of the real-time embedded programming framework should be pursued in this phase. Promotion of the programming technology through industrial consortia or other standardization activities is encouraged. Domain-specialization of the framework is also encouraged, e.g., for programming commercial embedded systems applications or consumer device product lines. Example applications might include manufacturing, environmental control, consumer electronics, medical devices, or automotive systems.

KEYWORDS: Embedded Systems, Real-Time Software, Aspect-Oriented Programming, Open Systems, Object-Oriented, Domain-Specific Languages, Programming Languages, Program Analysis, Program Transformation, Staging Analysis, Partial Evaluation, Micro-Protocols, Patterns, Model-Based Design.

DARPA ST00-005 **TITLE: Adaptive Optics for Micro-Platforms**

KEY TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Development of novel devices for adaptive micro-optics, their integration with electronic signal processing, and demonstration of new system concepts.

DESCRIPTION: The capability to produce micro-mechanical devices has provided design engineers with a new tool to control and enhance the performance of a wide variety of air, ground and maritime systems. Incorporation of these micro-mechanical devices into the design of optical systems extends their application base, providing a novel method to control optical signals in an integrated, solid state package. Adaptive micro-optical devices can add the ability to correct, shape and direct the optical signals prior to electronic signal processing, dramatically increasing processing power and performing a pre-processing function not possible with electronic processing. Previous work in adaptive optics used the mechanical motion of large mirrors and optical elements to modify the shape and response of the optical system. The physical size and cost of these adaptive optical elements restricts their application and limits performance to large platforms. The advent of solid state, micro-mechanical fabrication technology can dramatically change adaptive optics technology. The micro-mechanical, solid state technology will allow design and implementation of precisely controlled optical elements, which can be modified in real time, to optimize the performance of the optical system and direct optical beams within the optical system. Micro-mechanical adaptive optics permit the fabrication of compact optical systems ideally suited for the micro-platforms planned for future military systems. These platforms include micro-air vehicles, robotics, munitions and even man-portable systems. Application of adaptive optics technology, previous reserved for large aperture systems, adds to these small platforms a new level of performance. Examples of specific performance enhancements include an optical transfer function tailored to compensate for atmospheric disturbance, correction of imperfections in the optical system, new methods of image enhancement, and the potential to perform multi-spectral imaging with adaptive optical elements.

PHASE I: Develop an overall system concept for the incorporation of adaptive optical components. For the concept selected, formulate one or more feasibility designs, identify key technologies fundamental to the design, determine critical device specifications, assess risk areas, and demonstrate the performance of devices critical to the design. Describe the advantages of the adaptive optics design for the selected system concept.

PHASE II: Implement a specific design concept through the demonstration of a prototype sub-system. The sub-system demonstration will include the fabrication of micro-optical components, integration of components into the sub-system and performance evaluation. Formulate the specifications for the integration of the micro-optical sub-system into application system.

PHASE III DUAL USE APPLICATIONS: Integrate the micro-optical sub-system with the final system, and demonstrate performance for the selected application. Verify performance parameters outlined in Phase I, and address the potential for dual use applications. Potential dual use applications may include, but are not limited to, long range imaging, including space imaging; and imaging for the detection of biological and chemical species.

KEYWORDS: Adaptive Optics, Imaging Systems, Night Vision, Infrared Imaging

REFERENCES:
General Reference:
1. The Infrared and Electro-Optical Systems Handbook; Volume 8; Emerging Systems and technologies; Editor Stanley Robinson; Defense Technical Information Center, DTIC-FF, Cameron Station, Alexandria, Virginia 22304-6145.
References to Specific State of the art Micro-Optics Research
2. Micro-optic Requirements for Optically Assisted Winchester Recording Heads; Heanue John; SPIE – The International Society for Optical Engineers; Vol. 3776
3. High Precision Micro-optical Elements by Wafer Scale Replication on Arbitrary Substrates; Dannberg, Peter et al; SPIE - The International Society for Optical Engineers; Vol. 3739.

DARPA ST00-006 **TITLE: Imprint Tools for Patterning Nanostructures**

KEY TECHNOLOGY AREAS: Sensors, Electronics and Battlespace Environment.

OBJECTIVE: Develop nanoimprint machines that are suitable for patterning structures with critical dimensions in the nanometer regime.

DESCRIPTION: Nanoimprint lithography (NIL) is becoming an important method for low-cost and high-throughput patterning of nanostructures. No imaging optics are needed so many of the limitations associated with projection optical lithography are eliminated. In NIL, patterns are formed directly in a thin deformable layer by pressing a master (stamp) into the layer. This is accomplished at elevated temperatures (up to 150 C) and pressures (up to 300 pounds per square inch (psi)). However, no commercial tools are currently suitable or available for NIL. For example, commercially available presses cannot achieve the large-area uniformity needed for NIL and are not suitable for operation in a clean room environment. Furthermore, current commercial presses have a cycling time that is orders of magnitude longer than that required for a reasonable throughput with NIL. To make NIL a real manufacturing technology, it is essential to develop presses with the appropriate characteristics.

PHASE I: Perform a design study of NIL tools that offer the needed large-area uniformity (>4", scalable to 8"), cycling time (<5 min, scalable to <2 min), imprint pressure (max 300 psi) and imprint temperature (max 150 C), with clean-room compatibility. Identify the key parameters and application areas for such tools.

PHASE II: Develop the NIL tool prototype(s) according to the design study in Phase-I. Build and test prototype, and refine the design. Perform application driven demonstration. Design and develop automatic control system.

PHASE III DUAL USE APPLICATION: The new NIL tools will enable the manufacturing of many key military and civilian high-performance nanodevices, which are currently too expensive to manufacture with conventional technology. These devices include high-frequency Metal Semiconductor Field Effect Transistors (MESFETs), mass storage, optical filters, and other optical signal processing elements.

KEYWORDS: Sensors, Nanostructures, Imprint, Nanodevices

REFERENCE: Several papers describing NIL can be found in the Journal of Vacuum Science of Technology volumes B16(6), Nov/Dec 1998, and B17(6), Nov/Dec 1999.

DARPA ST00-007 **TITLE: <u>Enhanced Electromagnetic Prediction Capabilities</u>**

KEY TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and exercise rigorous radio frequency electromagnetic scattering code to predict and explain the backscatter properties of physical objects and various backgrounds. From insights gained by exercising the model throughout ranges of parameters, propose possible parametric features for classifying background types and object classes.

DESCRIPTION: Computational electromagnetics has shown considerable success at predicting radar returns from certain classes of target objects, when dealing with X band radar and typical operating characteristics [see reference 1]. New technology has made advances that considerably extend the operating environment of future radar systems. These advances include wideband electronics, new signal processing methods, and advanced algorithms. Ultrahigh resolution synthetic aperture radar (SAR) is available at X band and higher, and lower wavelengths are also now feasible for radar, where penetration of dielectric materials such as foliage and certain types of soil is possible. Ultra wideband (UWB) radar testbed's are now becoming available to validate the utility of such a sensor for detecting obscured targets. SAR imaging systems are typically used to detect targets [see reference 2]. Early empirical evidence supports the hypothesis that many objects found pervasively in nature will not return significant energy to such low wavelength radar. For instance, tree canopy and various grasses have very little backscatter at UHF frequencies and below. Alternately, large girth trees and other combinations of naturally occurring background are seen to have appreciable backscatter characteristics. These objects compete directly with man made targets for the attention of most modern target detection algorithms. Further complications ensue because of the wide variety and diversity of naturally occurring clutter, and due to the availability of wideband sensing systems. Computational electromagnetic code for these new operating environments would have applicability to (1) supplement data collections, obviating unrealistically expensive measurement programs, (2) algorithm development, by providing insight into phenomenology of RF returns, and (3) sensor design, by leading to better performance predictions through modeling, without expensive point designs. The developed code could be used to predict both the signatures from man made objects, and clutter which is widely diverse and statistical in nature. The insights available from a thorough evaluation of both target and clutter return as a function of illuminating angle, frequency and polarization basis would allow the developing of enhanced discrimination features in various detection algorithms under development at contractor and government facilities today. Through the development of advanced feature sets, high performance detection algorithms would be available for the UWB radar of tomorrow.

PHASE I: Develop and prototype electromagnetic predictive code that expands the range of applicability of existing methods. Apply the technique for one or more target vehicles and one or more clutter classes. Identify metrics for validating the predictive capability of the code versus actual measured data.

PHASE II: Develop and validate code, and exercise the model through a wide variety of target and clutter occurrences. Provide detailed findings on the backscatter properties of each class in terms of frequency, angle and polarization state. Propose an advanced feature set for use in characterizing background and object classes.

PHASE III DUAL USE APPLICATIONS: UWB radar will increasingly have commercial viability, and has the potential to provide remote sensing for a variety of agricultural, geo-physical and commercial applications. Examples abound and include the use of such a radar for: Detection of underground pipes and wires —a priority requirement for most electric and gas utility companies; determination of the maturity and harvest potential of crops such as trees grown for lumber; etc. Rigorous models, when available, would permit industry to assess the utility of UWB radar technology for these (and other) applications.

KEYWORDS: Sensors, Radar, Ultra Wideband, Synthetic Aperture Radar, Automatic Detection, Computational Electromagnetics.

REFERENCES:
1. D. J. Andersh, S. W. Lee and H. Ling, " high frequency electromagnetic scattering prediction code using shooting and bouncing rays," accessible at http://www.demaco.com/papers/sbr1/.
2. Chris Oliver and Shaun Quegan, *Understanding Synthetic Aperture Radar Images,* Artech House.

DARPA ST00-008 **TITLE: Advanced Tracking Techniques for FOPEN GMTI Radars**

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop innovative target tracking algorithms and sensor resource management techniques for application in airborne foliage penetration (FOPEN) radars.

DESCRIPTION: Airborne FOPEN radars are currently being studied by DARPA to detect and track ground moving targets on tree-lined roads and in wooded areas. These radars will operate at VHF or UHF to penetrate foliage. Even at these low frequencies, however, the foliage attenuation and backscatter will cause the target returns to have low signal-to-clutter-plus-noise ratios (SCNRs). FOPEN Ground Moving Target Indication (GMTI) radars will differ from conventional GMTI radars. First, they will have longer coherent integration times and coarser range and azimuths resolutions than conventional radars. Also, due to their broad beam widths, FOPEN radars will provide either very high target update rates or possibly even continuous target observations. Finally, the bandwidth of FOPEN GMTI radars may be limited to about 30 MHz due to spectrum allocation constraints. This might prohibit the use of high range resolution techniques to perform target association. However, FOPEN radars could provide multiple polarization (e.g. HH, VV and HV) data to enhance look-to-look target association. Tracking targets in heavily foliated areas will require new tracker concepts. The tracker must accommodate low SCNRs, high false alarm rates and false tracks. Furthermore, roads in wooded areas are likely to be much more winding than highways. It is therefore likely that traffic will exhibit continual changes in velocity, which exacerbates the tracking problem. Also, even with a FOPEN capability, the target visibility will occasionally cease, causing track dropouts that can severely impact performance if not properly handled. Innovative tracking concepts and algorithms are needed to realize the full potential of a FOPEN GMTI system. One approach for enhancing FOPEN radar performance might be to interface the tracker and the radar through a sensor resource manager (SRM). The SRM would control the waveform, coherent integration time, beam dwell time and target revisit rate to optimize performance. Additionally, a FOPEN GMTI radar might operate in concert with a passive ESM sensor to associate target emissions. Also SAR images, digital terrain elevation databases, land use and land cover databases, vector feature databases and other data about the area under surveillance might also be available to improve the tracking performance. FOPEN GMTI radar operation is discussed in Reference 1. FOPEN SAR imagery can be made available by DARPA. Additional databases can be obtained from the NIMA web site.

PHASE I: Develop an innovative concept for tracking targets with a FOPEN GMTI radar that has a relatively high false alarm rate and experiences frequent track dropouts. Show the benefits of utilizing additional data such as terrain databases, road locations, SAR images and ESM reports. Determine how an SRM might use these tools to enhance tracker performance.

PHASE II: Perform a software design of the Phase I tracker / SRM concept. Conduct computer analyses and demonstrate the tracker concept using realistic computer simulation techniques. Exercise the simulation to identify performance gains, risks and potential weaknesses.

PHASE III DUAL USE APPLICATIONS: The tracker techniques will be directly applicable for systems that track vehicles and personnel under foliage. Such systems are used in military operations, peace keeping missions, counter-drug operations, etc. The trackers could also be applied to civilian systems such as the airport surface detection equipment (ASDE-3) radar to enhance the monitoring of ground traffic in a severe clutter and multi-path environment.

KEYWORDS: FOPEN Radar, GMTI Radar, Target Tracking, Sensor Management.

REFERENCES: FOREST (FOPEN Radar and ESM for Targeting) Presentation to Industry (Available on DARPA web site).

DARPA ST00-009 **TITLE: Multi-Frequency/Multi-Phase Center SAR Processing for Foliage Canopy and Surface Clutter Suppression**

KEY TECHNOLOGY AREA: Sensors, Electronics

OBJECTIVE: Evaluate the potential of applying multi-phase center and/or multi-frequency SAR processing to suppress canopy clutter and surface clutter in support of detection of targets through foliage or in shallow underground hide.

DESCRIPTION: The capability of airborne SARs to perform foliage and ground penetration is severely limited by the strength of the "first surface" return. Conventional SAR imaging cannot separate this first surface scatter from the target backscatter by penetrating radiation. This is because there is insufficient independent information available from the single phase center used to form the synthetic aperture. The potential exists for enhancing selected targets beneath the first surface by acquiring multiple-aperture, and/or multiple-frequency data. This data could be processed in a manner to suppress the first surface scatter, which will provide a significantly enhanced view of an object beneath the foliage or surface. The purpose of this effort is to explore the data collection geometries, high-frequency and low-frequency assumptions, and signal processing options for suppressing the first surface scatter. Example techniques and concepts include:

(1) Use multiple apertures to generate a "interferometric images" to isolate the source of the penetrating backscatter.
(2) Use multiple polarization data (where available) to examine the capability for extracting "preferred polarization" geometries.
(3) Examine unexplained energy residuals that may be attributable to dispersion due to propagation through a frequency-dependent dielectric.

PHASE I: Perform a feasibility study of the phenomena involved with one or more types of multiple-parameter (e.g. aperture, polarization, and frequency) SAR imagery. Develop imaging concepts and data processing techniques that could collect and exploit the multiple-parameter data. Make theoretical predictions to show the benefits of the proposed techniques.

PHASE II: Generate prototype algorithms for the techniques that appear to have the potential to improve the SAR image characteristics. The prototypes should be developed using software tools such as MATLAB. Apply the algorithms to either data that will be provided by DARPA or to data obtained through other sources to confirm the theoretical performance predictions. Formalize the algorithms in a language such as C or C++ to provide maximum speed and flexibility. Quantify the capabilities of the best performing concepts.

PHASE III DUAL USE APPLICATIONS: The successful demonstration and software instantiation of the multi-parameter SAR imaging technologies will provide the capability to improve the accuracy of topographic maps. It will also improve the imaging of buried objects such as pipes and electrical conductors. The techniques would also benefit the conducting of search-and-rescue missions and performing other such radar mapping activities from an airborne platform. The technology would also have a humanitarian application in locating mine fields in areas such as the Balkans and Southeast Asia.

KEYWORDS: FOPEN SAR, Interferometric SAR, Ground Penetration Radar, Polarimetric Processing

REFERENCES:

1. B. C. Brock and W. E. Patitz, "Optimum Frequency for Subsurface-Imaging Synthetic Aperture Radar", Sandia Report SAND93-0815, Sandia National Laboratories, Albuquerque, NM, May 1993.
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